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EXHAUST EMISSIONS FROM TWO PASSENGER VEHICLES EQUIPPED WITH FUMCELL

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Environmental Protection Agency
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16. Abstracts As part of an evaluation of vehicular emission control devices, a test program was initiated to determine the emission reduction potential of the "FUMCELL". The device was installed in the PCV line of a 1970 Chevrolet Impala and a 1970 Plymouth Valiant. The Impala is equipped with an automatic transmission and a 350 cubic inch displacement, high compression, 8 cylinder engine. The Valiant is equipped with an automatic transmission and a 225 cubic inch displacement, 6 cylinder engine. The following emission tests were performed: Impala - 8 baseline 1972 Federal Test Procedure (FTP), 3 Fumcell-equipped 1972 FTP; Valiant - 1 baseline 1968 FTP with Constant Volume Sampling (CVS), 1 Fumcell-equipped 1968 FTP with CVS, 6 baseline 1972 FTP, 4 Fumcell-equipped 1972 FTP. In addition to these tests, fuel consumption was measured, and flow versus vacuum tests were conducted. The following conclusions were drawn from test results: (1) hydrocarbon and carbon monoxide emissions from both vehicles were substantially reduced by the installation of the Fumcell; (2) fuel consumption effects ranged from a 9 percent savings on the Valiant to a 7 percent penalty on the Impala.

17. Key Words and Document Analysis. 17a. Descriptors

Air pollution
Exhaust emissions
Automobiles
Crankcases
Tests
Standards
Fuel consumption
Sampling
Carbon monoxide
Carbon dioxide
Hydrocarbons
Nitrogen oxides

17b. Identifiers/Open-Ended Terms

Fumcell
Federal Test Procedure (1972)
Constant Volume Sampling Technique (CVS)
Positive crankcase ventilation

17c. COSATI Field/Group 13B

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
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Device Tested

As part of a continuing evaluation of available vehicular emission control devices, the Test and Evaluation Branch initiated a test program to determine the emission reduction potential of the "Fumcell". Fumcell is a product of Energy Sciences Incorporated of El Segundo, California. The "Fumcell" is a small device, tubular in shape, which is installed in the PCV line according to the manufacturer's instructions. The standard PCV valve is left in place.

Vehicles Utilized

Two cars from the EPA fleet were used to evaluate "Fumcell's" effectiveness. The device was installed in the PCV line of a 1970 Chevrolet Impala and a 1970 Plymouth Valiant. The Impala is equipped with an automatic transmission and a 350 cubic inch displacement, high compression, eight cylinder engine. The Valiant is equipped with an automatic transmission and a 225 cubic inch displacement, six cylinder engine. Indolene 30 was used for testing of the Impala while Indolene Clear was utilized for the Valiant. Extensive baseline emission data were available on each of these passenger cars.

Emission Test Procedure

The following emission tests were performed (all tests were cold start):

Impala

8 Baseline 1972 Federal Test Procedure (FTP)

3 Fumcell-equipped 1972 FTP

Valiant

1 Baseline 1968 FTP with Constant Volume Sampling (CVS)

1 Fumcell-equipped 1968 FTP with CVS

6 Baseline 1972 FTP

4 Fumcell-equipped 1972 FTP

The 1968 FTP was performed in accordance with the June 4, 1968, Federal Register, Volume 33, Number 108. The 1972 FTP was performed in accordance with the November 10, 1970, Federal Register, Volume 35, Number 219. Closed cycle data in each case were taken utilizing the constant volume sampling technique. Bag samples were analyzed using non-dispersive infrared analysis for carbon monoxide and carbon dioxide. Hydrocarbons were measured using a flame ionization detector. Oxides of nitrogen were determined utilizing the Saltzman analysis--a wet chemical technique. Non-dispersive infrared analysis was utilized for open cycle, continuous analysis of hydrocarbon, carbon monoxide, carbon dioxide, and nitric oxide in the 1968 FTP.

Additional Tests Conducted

In addition to the emission tests described in the previous section, two other tests were employed to further evaluate the "Fumcell".

Fuel consumption was measured during each emission test. The test fuel tank was weighed prior to and immediately following each emission test.

Because the "Fumcell" depends on altering the characteristics of the PCV system for its effectiveness, flow versus vacuum tests were conducted. These tests spanned two ranges to measure the effect on PCV flow at both high and low vacuum. Testing was performed on a standard flow bench. Low vacuum utilized water as a pressure measuring fluid while it was required to use mercury for high vacuum measurements.

Emission Results

Complete emission data for the 1970 Valiant are presented in Table 1 of this report. Utilizing the open cycle 1968 FTP, the employment of Fumcell resulted in measured reduction of 28 percent in hydrocarbons and 63 percent in carbon monoxide. Nitric oxide emissions appeared to increase by 3 percent. Closed cycle or CVS data obtained simultaneously by repeating the 7-mode cycle nine times while taking a bag sample, indicated actual mass emission reductions of 45 percent in hydrocarbons, 53 percent in carbon monoxide, and 24 percent in oxides of nitrogen. Similarly, utilizing the 1972 FTP, mass emissions from the Valiant were reduced by 28 percent in hydrocarbons, 48 percent in carbon monoxide, and 10 percent in oxides of nitrogen.

Emission data for the 1970 Impala are also presented in Table 1 of this report. Use of the 1972 FTP revealed that hydrocarbon emissions were reduced by 22 percent, carbon monoxide by 48 percent. A 4 percent increase in oxides of nitrogen were shown.

Fuel Consumption Results

Fuel consumption data for both the Impala and the Valiant are presented in Table 2. The Valiant equipped with Fumcell showed an 8 percent reduction in fuel consumption during the 1968 FTP evaluations and 9 percent during the 1972 FTP. On the other hand, the Impala used 7 percent more fuel during 1972 FTP tests when equipped with Fumcell.

PCV Flow Test Results

The effect of the "Fumcell" on flow through a PCV system is indicated on Figures 1 and 2 of this report. Figure 1 depicts flow under low vacuum conditions from 0-30 inches of water vacuum. Although flow initially begins at about 6 inches of water both with and without the Fumcell in place, from 6 inches to 30 inches of water the flow through the system equipped with Fumcell is restricted up to about 40 percent of normal flow.

Under high vacuum conditions use of the Fumcell results in the bleeding in of additional air. As Figure 2 indicates from 12 inches of mercury to higher vacuums flow through the PCV system tested remained constant. Without Fumcell this flow was about 2 cubic feet per minute (cfm). With Fumcell the flow increased to 4.5 cfm, an increase of 125 percent under idle type conditions.

Conclusions

1. Hydrocarbon and carbon monoxide emissions from both the Impala and Valiant were substantially reduced by the installation of the Fumcell. This reduction was caused by the high vacuum leaning effect of the Fumcell. It is felt that while both cars tested were running rich enough to tolerate this leaning effect the same effect could be accomplished by adjusting the carburetion on both cars. A leaner running vehicle would probably develop adverse driveability affects with installation of the Fumcell. The restriction of PCV flow at low vacuum (acceleration conditions) has little effect because the PCV flow is a much smaller proportion of total flow into the intake manifold. Oxides of nitrogen did not react consistently to the installation of Fumcell. Increasing NO_x emissions from the Impala indicate the potential result of the leaning effect. The decrease in NO_x emitted by the Valiant appears questionable as the last two baseline tests reported are both lower than the average Fumcell equipped NO_x emissions during the 1972 FTP. It is felt therefore that Fumcell has little direct effect on NO_x emissions.

2. Fuel consumption effects ranged from a 9 percent savings on the Valiant to a 7 percent penalty on the Impala. No conclusion as to Fumcell's effect on fuel consumption can be made.

3. While Fumcell seems to be an effective device for leaning vehicular operation, it is doubtful that it is universally applicable to a population of vehicles with operating conditions ranging from very rich to very lean.

Table 1

Emission Data

1970 Valiant 225 CID

1968 FTP - 7-mode, open cycle

Baseline	HC ppm	CO %	*NO ppm
Trip Composite	162.1	1.29	1951.1
Fumcell			
Trip Composite	116.0	0.48	2011.3
% Reduction	28%	63%	3% increase

9 cycle - 7-mode, closed cycle

Baseline	HC gpm	CO gpm	CO_2 gpm	Saltzman *NO_2 gpm
	3.20	43.89	398.42	7.44
Fumcell				
	1.77	20.54	388.33	5.65
% Reduction	45%	53%	3%	24%

1972 FTP, LA 4-S4, closed cycle

Baseline	HC gpm	CO gpm	CO_2 gpm	Saltzman *NO_2 gpm
Before	3.73	67.59	447.39	6.40
Fumcell	2.53	42.65	282.41	7.17
	2.51	29.80	439.79	6.48
	2.79	53.73	542.93	7.10
After	2.57	43.63	425.62	4.89
Fumcell	2.53	50.69	417.88	5.57
Average Baseline	2.78 gpm	48.02 gpm	426.00 gpm	6.27 gpm
Fumcell				
	2.16	27.77	478.11	5.34
	1.66	26.71	443.99	5.83
	2.18	19.99	437.29	5.82
	1.98	27.12	442.69	5.49
Average Fumcell	2.00 gpm	25.40 gpm	450.52 gpm	5.62 gpm
% Reduction	28%	48%	6% increase	10%

* corrected for temperature and humidity

Table 1 (cont'd)

Emission Data (cont'd)

1970 Impala 350 CID

1972 FTP - LA 4-S4, closed cycle

Baseline	HC gpm	CO gpm	CO_2 gpm	Saltzman *NO_2 gpm
Before Fumcell	4.65	49.63	610.9	4.9
	4.36	45.01	611.7	5.3
	4.36	44.10	561.3	5.8
	4.29	45.35	544.7	4.9
After Fumcell	4.47	47.01	605.9	5.9
	6.27	53.77	566.3	5.0
	5.96	58.80	495.5	4.6
	4.24	45.00	610.1	5.3
Average Baseline	4.83 gpm	48.60 gpm	575.8 gpm	5.2 gpm
Fumcell				
	3.21	25.43	567.7	5.9
	4.11	23.41	590.3	4.8
	4.05	26.94	628.8	5.4
Average Fumcell	3.79 gpm	25.26 gpm	595.6 gpm	5.4 gpm
% Reduction	22%	48%	3% increase	4% increase

Table 2

Fuel Consumption Data

1970 Valiant 225 CID

9 Cycle - 7-mode

Baseline	1.250 kg.
Fumcell	1.150 kg.
% Savings in fuel consumption	8%

1972 FTP - LA 4-S4

Baseline	1.455 kg.
	1.210
	1.480
	1.280
	1.207
Average	1.326 kg.
Fumcell	1.230 kg.
	1.178
	1.200
	1.195
Average	1.201 kg.
% Savings in fuel consumption	9%

Table 2 (cont'd)

Fuel Consumption Data (cont'd)

1970 Impala 350 CID

1972 FTP - LA 4-S4

Baseline		1.63 kg.
		1.59
		1.64
		1.59
		1.82
		1.71
		1.84
	Average	1.69 kg.
Fumcell		2.02 kg.
		1.79
		1.62
	Average	1.81 kg.

% Penalty in fuel consumption 7%

Figure 1

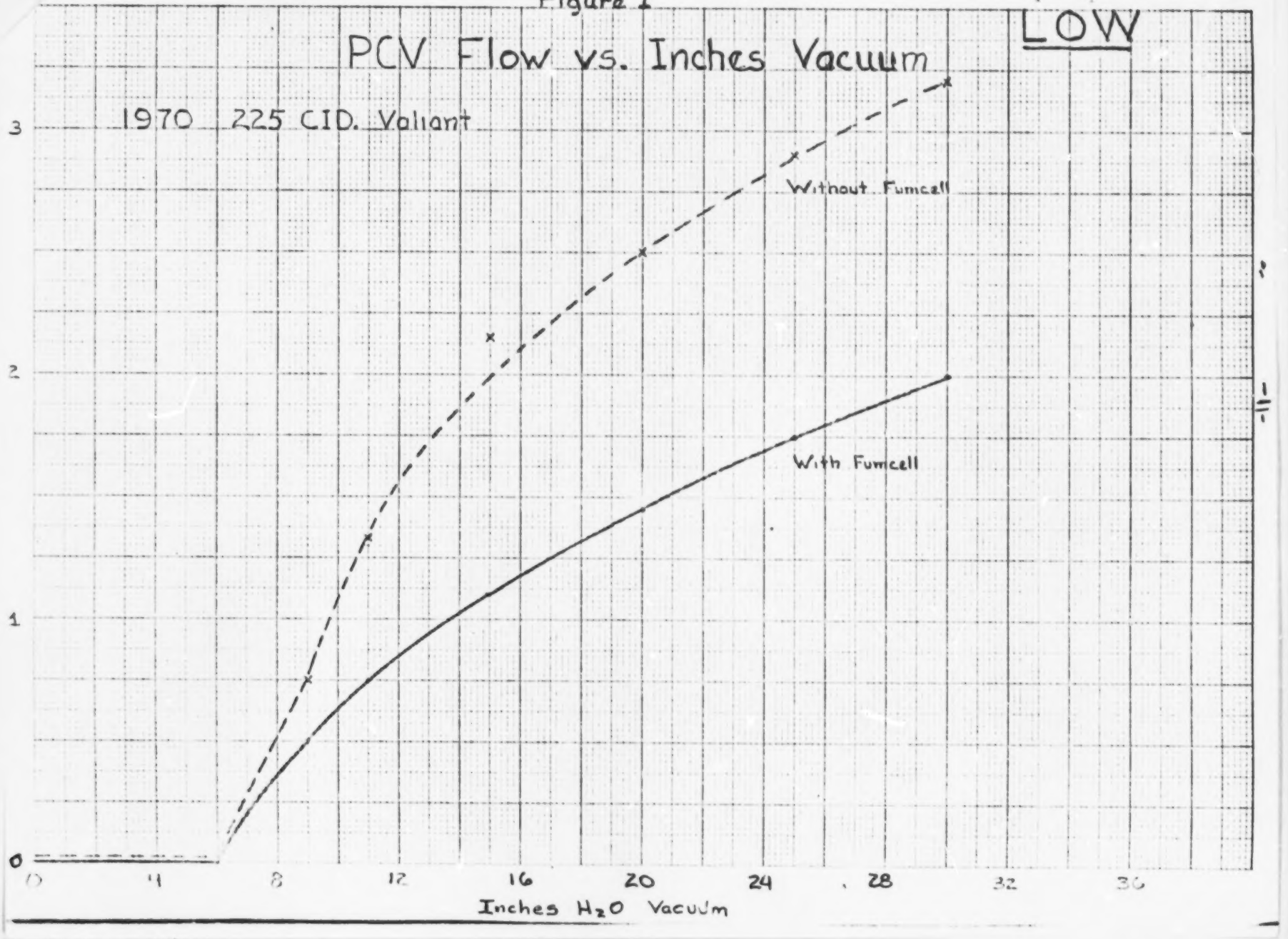
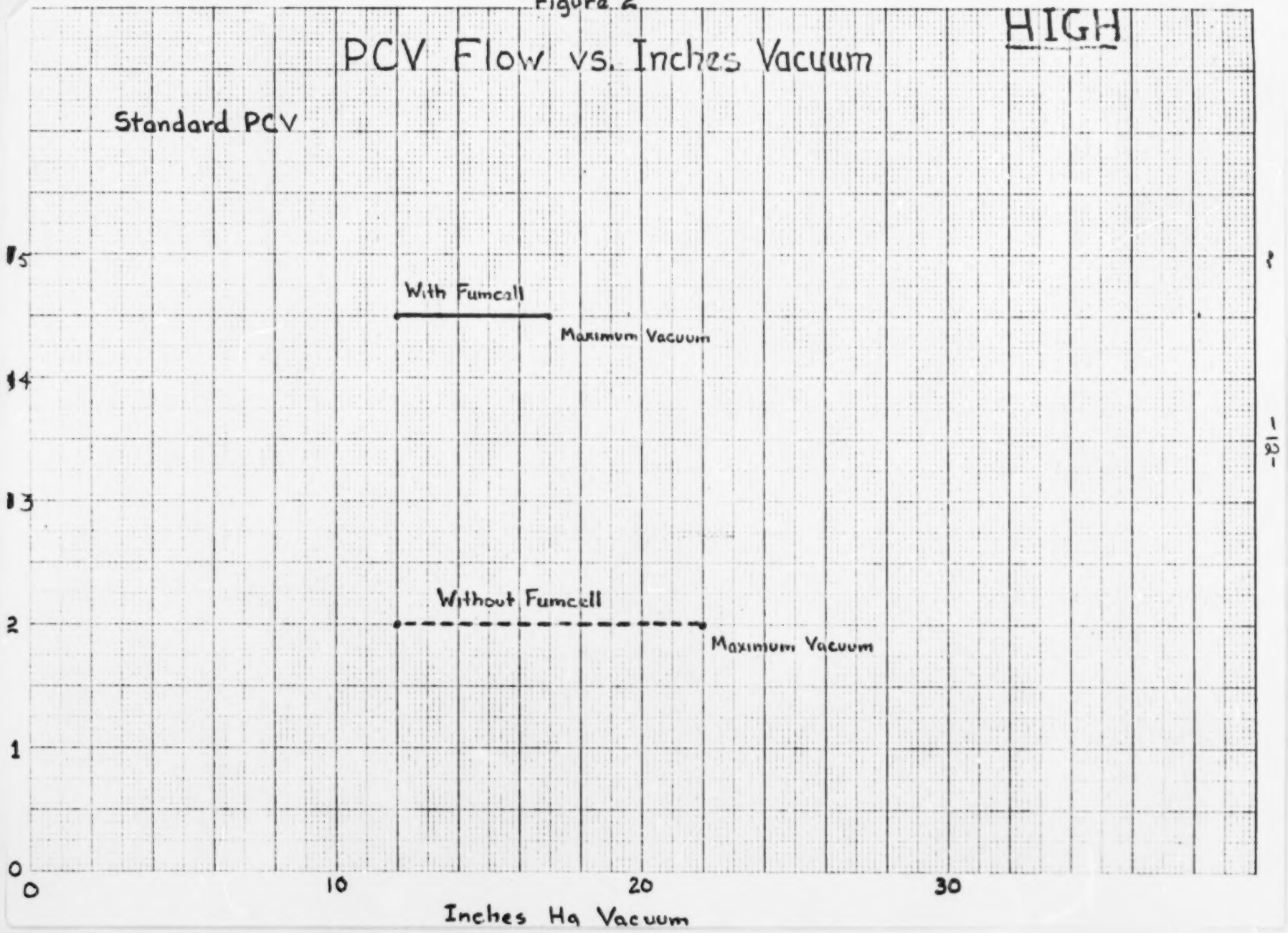

PCV Flow vs. Inches Vacuum
LOW
1970 225 CID. Valiant
Without Fumcell
With Fumcell
3
2
1
0
0
4
8
12
16
20
24
28
32
36
Inches H₂O Vacuum

Figure 2


PCV Flow vs. Inches Vacuum
HIGH
Standard PCV
15
14
13
2
1
0
With Fumcell
Maximum Vacuum
Without Fumcell
Maximum Vacuum
0
10
20
30
Inches Hg Vacuum